Managing rhodes grass (*Chloris gayana*) cv. Callide to improve diet quality.
2. Effects of stocking rate and irrigation frequency

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Abstract

The effects of stocking rate and irrigation frequency on the milk production of cows grazing nitrogen-fertilised Callide rhodes grass pastures was studied in south-east Queensland. Pastures were stocked at 3.5, 5.25 and 6.1 cows/ha from January–May inclusive, and irrigated at fortnightly or monthly intervals.

Yields on offer pregrazing and pasture, leaf and stem residues after grazing decreased at the higher stocking rates. Consumption of grass leaf averaged 10.6, 7.7 and 6.5 kg DM/cow/d for cows grazed at 3.5, 5.25 and 6.1 cows/ha, respectively ($P<0.05$). Intake of stem averaged 1.3 kg DM/cow/d, with no difference between treatments ($P>0.05$). Milk yields averaged 16.6 kg/cow/d for Weeks 7–18 and were unaffected by treatment. Liveweight loss in the first 15 weeks of the experiment averaged 15, 28 and 43 kg at 3.5, 5.25 and 6.1 cows/ha, respectively ($P<0.05$). Cows stocked at 3.5/ha recovered liveweight during the experiment, but liveweight losses continued for cows at 5.25 and 6.1 cows/ha.

Rhodes grass management should aim to harvest a high proportion of leaf, a result which was achieved under a wide range of stocking rates in this experiment. Reducing the frequency and total volume of irrigation resulted in reduced levels of soil water and pasture yield, but did not affect milk production until the final 3 weeks of the experiment (May).

The stocking rate of 3.5 cows/ha allowed cows to maintain body weight and appears optimal for these pastures.

The ability of the pastures to maintain DM yield with half the applied water input demonstrates that efficiencies may be gained by closer monitoring of soil and pasture production in autumn rather than the normal practice of fortnightly watering. This, combined with the longer grazing interval of 6 weeks and a stocking rate of 3.5 cows/ha, provided the most efficient use of the tropical grass pasture resource in late summer and autumn.

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Introduction

In a previous experiment, Ehrlich *et al.* (2003) demonstrated the capacity of tropical grasses to support stocking rates of 3.7 cows/ha with only small differences in diet quality and milk production on different grazing management options. These pastures were seen to have special roles: to carry a high stocking rate from January–April inclusive; to provide the forage base in the ration during this period when temperate pastures were inactive; and to do this with minimal inputs of land, water and fertiliser. A consequence of this would be that land, water and fertiliser could be partly diverted to crops with higher feed value, such as maize for silage, lucerne and legume forage crops.

In addition to land, water is a limiting resource on dairy farms (Cowan 2000). Irrigation used on tropical grasses could potentially be used on forage crops or temperate pastures. The main growth season of tropical grasses coincides with the period of highest rainfall in northern Australia. Consequently, there is a need to determine the most efficient way to utilise irrigation on tropical grass pasture. The present experiment was designed to measure the impact on milk production of stocking rates above those used in the previous experiments (Ehrlich *et al.* 2003), and to obtain preliminary information on the potential to reduce irrigation water inputs to these pastures.

Materials and methods

The experiment was carried out in 1995 on Mutdapilly Research Station, south-east Queensland (27° 45'S, 152° 40'E; elevation 40m), where the climate is subtropical with a mean annual rainfall of 850mm, of which 60% falls between December and March. Rainfall was 327 mm for the 5 months (Jan–May). This was below the long-term average of 406 mm with only 2 mm being recorded in April and 10 mm in May. These are below the long-term averages of 85 and 76 mm for these months, respectively. Mean maximum and minimum temperatures are 31 and 18°C in December and 20 and 5°C in July, respectively. Frosts can occur from May to September, but are most common in June, July and August.

The experiments used 7.2 ha of mixed black and brown cracking clay soils, classified as endohypersodic, self-mulching black and grey vertosols (Isbell 1996).

Rhodes grass (*Chloris gayana*) cv. Callide was established on the area in 1982, and in the 5 years preceding the present experiment, the area received 150 kg/ha N and 250 kg/ha superphosphate annually, and 125 kg/ha potassium chloride in alternate years. In 1992–1994, the maintenance applications of phosphorus and potassium were continued, and urea was applied at 300 kg N/ha/yr, on a schedule of 50 kg/ha N each month from October–March, inclusive. Urea was applied within the 24 h before irrigation. The rhodes grass area was divided into 2 blocks, and each block further subdivided into four 0.9 ha paddocks. Treatments were allocated at random to the 4 paddocks in each block. Pastures were mulched in late October and late November to precondition them to a 6-week grazing rotation. Throughout the experiment, the area was further divided using electric fences and pastures were grazed in a 6-paddock rotation, with open grazing of each paddock for 1 week. Paddocks were mulched to 10-cm stubble after each grazing. A 6-week rotation was chosen to increase the probability of a substantial rainfall event at some time during the rotation compared with a 4-week rotation and previous research had shown similar animal and pasture performance with 2, 4 and 6-week rotations (Ehrlich *et al.* 2003). Pastures were irrigated with approximately 25 mm water each fortnight unless rainfall made this unnecessary, except for Treatment 3.5H which was watered monthly.

Holstein-Friesian cows entered the experiment on January 4, 1995 for 18 weeks (3 cycles of 6 weeks) and remained on the pasture day and night, alternating weekly between blocks. Drinking water and shade were available in all paddocks, and animals received 5 kg of a cereal grain-based concentrate daily. The crude protein concentration in this concentrate was adjusted to 16% using cottonseed meal or meat and bone meal, and a mineral premix was added. No other supplements were given.

The treatments were: (i) 3.5 cows/ha (3.5); (ii) 5.25 cows/ha (5.25); and (iii) 6.1 cows/ha (6.1). A fourth treatment (3.5H) was stocked at 3.5 cows/ha and pastures were irrigated monthly rather than fortnightly. The pastures were fertilised with 300kg/ha N over the growing season.

Twenty-one Holstein-Friesian cows and heifers calving in October and November were blocked on milk yield during December and within blocks allocated at random to a non-orthogonal design using 4, 6, 7 and 4 cows for treatments (i)–(iv), respectively. Milk yield was recorded at 2 consecutive milkings each week (pm/am), and a composite sample taken for analysis of fat, protein and lactose (Fossomatic-Milkoscan 203). Cows were weighed fortnightly following morning milking.

Pasture on offer was determined each week by cutting 12 randomly selected 0.25m^2 quadrats to 10 cm stubble height from the paddock to be grazed for the next week. Pasture from the 12 quadrats was bulked and weighed, and 2 subsamples of 500g taken for determination of DM by drying at 80°C for 24 h in a forced-draught oven, and for estimating leaf, stem and dead proportions in the DM by hand sorting and drying as above. Leaf and stem samples were bulked over 3-week periods, ground through a 1 mm screen and analysed for *in vitro* DM digestibility (IVDMD) using the modified technique of Goto and Minson (1977), neutral detergent fibre (NDF) (van Soest 1967) using a Fibretec Analyser (Tecator AB, Sweden), and crude protein (CP) using a Leco FP-428 Nitrogen Determinator. Residual pasture was measured as described above.

Soil water content was monitored using 3 access tubes measuring from 0.15m to 0.8 m in

0.05 m increments weekly for treatment paddocks 3.5 and 3.5H using a field-calibrated neutron soil water probe.

Milk yield and liveweight data were analysed using a non-orthogonal analysis of variance. The area of rhodes grass available for this experiment was fixed from the previous studies, and since this study concentrated on stocking rates, a non-orthogonal design was used to adjust the cow numbers in the fixed size treatment paddocks. Pasture on offer was analysed by analysis of variance.

Results

Pasture yield on offer to cows averaged 4300 kg/ha DM during Cycle 1 and did not differ (P>0.05) between treatments. During Cycles 2 and 3, treatment effects were more evident (Table 1), with yield of total pasture, leaf and stem decreasing (P<0.05) at the highest stocking rate. Irrigation frequency had no effect on mean pasture yield. Leaf and stem proportions in pasture were not altered by treatment. Leaf yield decreased from Cycle 2 (2259 kg/ha DM) to Cycle 3 (1745 kg/ha DM), but yields of stem were similar in both cycles (P>0.05).

Pasture residues following grazing were also lower at the high stocking rates, with almost all DM removed being leaf (Table 2). From differences in pasture yield before and after grazing and pasture growth during the grazing period, an estimate of utilisation by the cows was calculated. Apparent intakes of leaf averaged 8.9, 10.6, 7.7 and 6.5 kg DM/cow/d for treatments 3.5H,

Table 1. Mean total yield of pasture and grass leaf and stem yields on offer to cows during Weeks 7–18 of the experiment.

Pasture measurement	Treatment[1]			
	3.5H	3.5	5.25	6.1
Yield (kg/ha DM)				
— grass leaf	2098ab[2]	2153b	1947ab	1811a
— grass stem	1519b	1476ab	1309ab	1109a
— dead	167	159	193	157
— total	3784b	3788b	3449ab	3077a
Composition (% DM)				
— grass leaf	55.1	57.7	59.0	58.5
— grass stem	39.7	37.9	36.2	35.5

[1] 3.5H = 3.5 cows/ha, irrigation monthly;
3.5 = 3.5 cows/ha, irrigation fortnightly;
5.25 = 5.25 cows/ha, irrigation fortnightly;
6.1 = 6.1 cows/ha, irrigation fortnightly.
[2] Within rows, values followed by different letters are different (P<0.05).

Table 2. Mean total yield of pasture residues and grass leaf and stem yields following grazing during Weeks 7–18 of the experiment.

Pasture measurement	Treatment[1]			
	3.5H	3.5	5.25	6.1
Yield (kg/ha DM)				
— grass leaf	1204c[2]	1014bc	622ab	507a
— grass stem	1777b	1517b	1213ab	901a
— dead	484	386	374	347
— total	3465c	2917bc	2209ab	1755a
Composition (%DM)				
— leaf	32.5	35.5	27.8	28.9
— stem	49.5	50.9	53.3	52.2

[1] 3.5H = 3.5 cows/ha, irrigation monthly;
3.5 = 3.5 cows/ha, irrigation fortnightly;
5.25 = 5.25 cows/ha, irrigation fortnightly;
6.1 = 6.1 cows/ha, irrigation fortnightly.
[2] Within rows, values followed by different letters are different (P<0.05).

3.5, 5.25 and 6.1, respectively (P<0.05). Utilisation of stem averaged 1.3 kg DM/cow/d, and was not different between treatments (P>0.05).

There were no effects of treatment on crude protein and NDF concentrations in pasture, mean values before grazing being 12.7 and 75.2% for leaf and 8.1 and 77.7% for stem. Post-grazing leaf contained 12.5 and 74.5%, and stem 6.9 and 80.5% crude protein and NDF, respectively.

Milk yield and composition

During Weeks 7–18, milk yield averaged 14.2, 15.3, 17.3 and 17.4 kg/cow/d for treatments 3.5H, 3.5, 5.25 and 6.1, respectively. The differences between Treatments 3.5, 5.25 and 6.1 were not significant (P>0.05) and 3.5 and 3.5H were not significantly (P>0.05) different, though the mean value for the fortnightly irrigated treatments was significantly higher than that of treatment 3.5H (P<0.05).

Milk composition did not differ (P>0.05) between treatments and averaged 4.2% milk fat, 2.92% protein and 4.91% lactose.

Liveweight

Cows stocked at 3.5/ha maintained liveweight during the experiment, but those at 5.25 and 6.1 cows/ha suffered substantial weight loss with the magnitude of the loss directly related to stocking rate (Figure 1). Liveweight loss in the first 15 weeks of the experiment averaged 15, 28 and 43 kg at 3.5, 5.25 and 6.1 cows/ha, respectively (P<0.05).

Soil water balance

By adding irrigation and rainfall volumes and subtracting evaporation pan losses, a cumulative water balance for the pastures was calculated (Figure 2). There were substantial variations in water balance between weeks, and an increasing difference between the 2 levels of irrigation in late autumn.

Soil water content as measured by neutron probe was higher with full irrigation, though this difference was small in February following rain and increased progressively from then through to

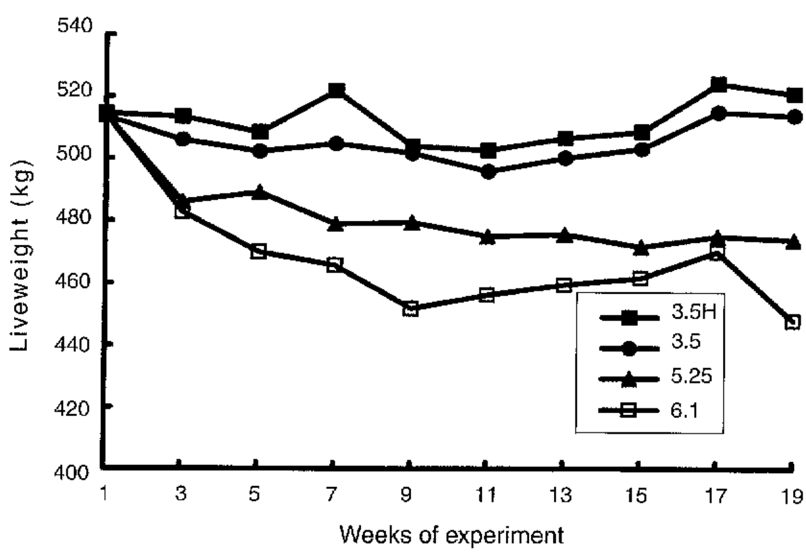

Figure 1. Effect of treatment on liveweight of cows during the experiment. Treatments were:
3.5H = 3.5 cows/ha, irrigation monthly;
3.5 = 3.5 cows/ha, irrigation fortnightly;
5.25 = 5.25 cows/ha, irrigation fortnightly; and
6.1 = 6.1 cows/ha, irrigation fortnightly.

May (Figure 3). There was no variation in water content of soil at depths greater than 80 cm, indicating pasture was not using water from below this level.

The effects of half irrigation on pasture yield on offer began to be evident in February, and thereafter increased except for short periods following significant rainfall events (Figure 4). By contrast, the effect on milk yield was not evident until the last month of the experiment (Figure 5).

Discussion

The irrigated tropical grass pasture was not adversely affected by the high stocking rates. The data indicate that regrowth rates, leaf percentage and chemical components were maintained at a stocking rate of 6.1 cows/ha. Murtagh *et al.* (1980) showed that intensively managed kikuyu pastures were able to sustain very high grazing pressures, and Robbins *et al.* (1989) and Cowan *et al.* (1995) showed that, at nitrogen fertiliser levels above 100 kg N/ha/yr, dryland tropical grass pastures maintain a vigorous, weed-free sward, even at stocking rates above 2 cows/ha over the whole summer and autumn season.

However, cows were affected by the high stocking rates (5.5 and 6.1 cows/ha) in our study. In our experiment, all cows received a common level of supplementary feeding and, at the higher stocking rates, cows were apparently not able to

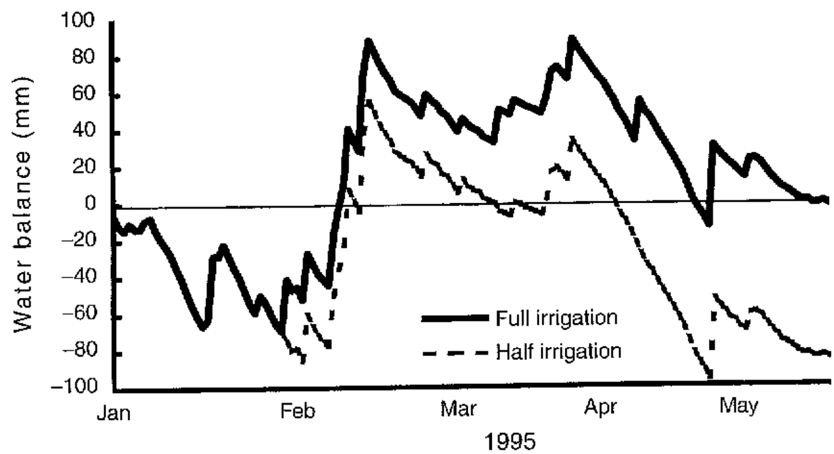

Figure 2. Calculated cumulative water balance for pastures receiving half and full irrigation during summer and autumn.

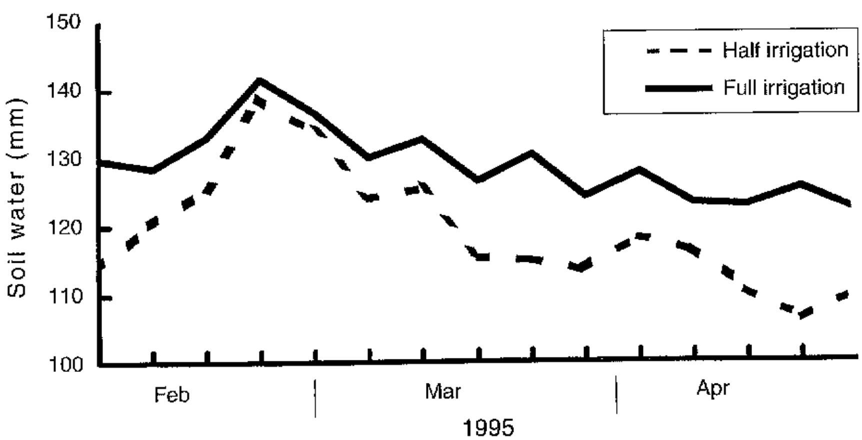

Figure 3. Measured soil water content to a depth of 0.8 m for pastures stocked at 3.5 cows/ha and receiving half or full irrigation.

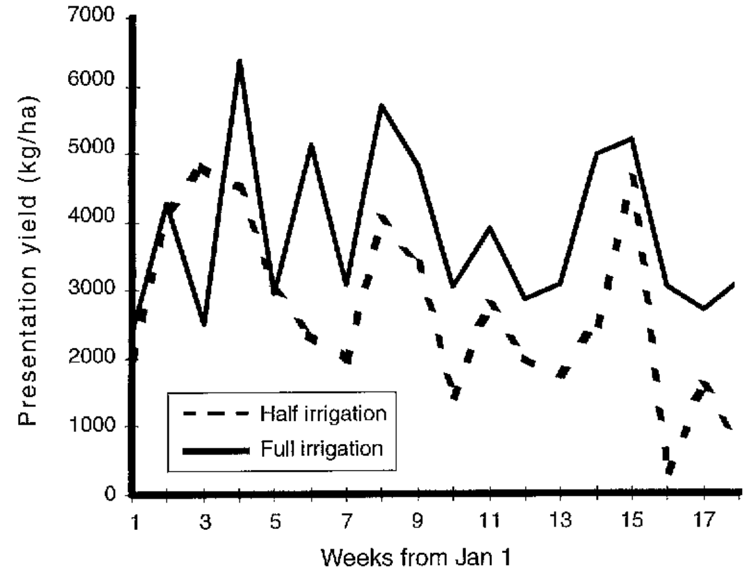

Figure 4. Pasture yield on offer for rhodes grass pastures receiving half and full irrigation and stocked at 3.5 cows/ha.

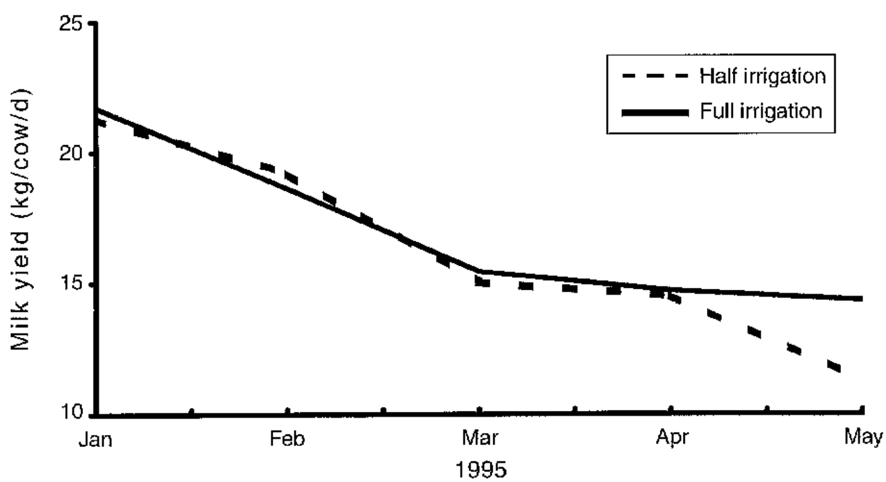

Figure 5. Daily milk yield of cows stocked at 3.5 cows/ha on rhodes grass pastures receiving half or full irrigation.

harvest sufficient grass to maintain liveweight despite high post-grazing yields, though milk yield was maintained. This indicates that either grazing behaviour or leaf inaccessibility limited intakes. This is supported by the high stem percentage (52%) and low leaf presentation yields (507 kg/ha DM) in the 6.1 cows/ha post-grazing pasture. Using standard values for the energy equivalent of liveweight gain (NRC 1989), we calculated that the energy provided by the liveweight loss accounted for a large part (60%) of the energy needed to maintain milk production relative to the lower stocking rates of 3.5 and 3.5H. The balance of difference in milk yield is likely to be experimental error associated with factors such as the genetic differences between cows which was not considered in the blocking and the length of the experiment. The two higher stocking rate treatments were not in a homeostatic state for liveweight and cows continued to lose weight throughout the experiment while the 3.5 and 3.5H treatments maintained liveweight. The results also suggest that the relatively short length of the experiment did not allow full expression of treatment differences as the high stocking rate cows were still losing weight, even though this did not affect milk yield. It is suggested that the genetic predisposition of the cows to produce milk had higher expression than the need to preserve bodyweight. Obviously, these cows could not sustain a similar continued weight loss over a longer period without affecting subsequent milk production. We are suggesting, however, that the length of the experiment was insufficient to express the point where liveweight loss significantly affected milk yield in the higher stocking rate treatments. This needs further investigation to quantify the factors involved in this result. However, under a practical farming system, using these pastures under high grazing pressure (>5 cows/ha), there would need to be a substantial input of supplement to maintain total dry matter intakes and increase energy intakes to maintain both milk yields and liveweight.

As observed previously (Ehrlich *et al.* 2003), cows consumed a high leaf proportion in their diet, 85% on average. Using mean leaf growth rate measured by Ehrlich *et al.* (2003), *i.e.* 42 kg DM/ha/d, this result indicates almost 100% utilisation of leaf at 6.1 cows/ha, compared with 86% at 3.5 cows/ha. The high utilisation of leaf in these pastures has been observed previously (Cowan *et al.* 1993) and further gains in productivity per hectare will be achieved only through boosting leaf growth rates. Cowan *et al.* (1995) suggested leaf growth rates are close to maximum at 300 kg N/ha/yr, and dry matter accumulation rates in cutting experiments are consistently in the range 80–120 kg DM/ha/d (Colman 1971). Given that most of these experiments used regrowth intervals of 6–12 weeks, the proportion of this growth as leaf would be in the order of 50% (Davison *et al.* 1985). Thus, mean leaf growth would be 40–60 kg DM/ha/d. Consequently, this experiment gives an indication of the potential leaf harvest from this grass.

Our preliminary observations have indicated there could be savings in water applied to tropical pastures during summer and autumn. Rainfall was below average during this period in our experiment, yet we measured only modest differences from a 50% reduction in irrigation. The full irrigation treatment aimed to supply 0.7 of the evaporation as measured by a standard evaporation pan. This indicator of pasture requirements appeared to be a less than optimal measure when evaporation rates, pasture growth and rainfall are declining through the autumn period. The differences in milk yield were entirely in the third cycle when rainfall was low and pastures were rapidly maturing. Previous research with dryland tropical grass pastures has shown them to be very efficient at extracting water, and often lack of nitrogen limits growth more than does lack of water (Henzell 1963; Buchanan *et al.* 1985). This indicates that the development of strategies and tools to allow irrigation to be scheduled to coincide with pasture growth requirements would be useful.

One important factor in intensively managed dairy pastures is continuity of grass supply. The results of Ehrlich *et al.* (2003) had shown no penalty to diet quality with an extension of regrowth interval to 6 weeks. Many experiments measuring dry matter production under cutting use a long regrowth interval of 6–12 weeks (Colman 1971; Cowan *et al.* 1995), and while total dry matter production is high, there may be periods of 3–4 weeks when moisture stress prevents growth of grass. In our experiment, we attempted to overcome this moisture stress effect by using a 6-week rotation, on the basis that, at some time in any 6-week period during summer and autumn, there would be a substantial rainfall event and subsequent rapid pasture regrowth. This strategy may have also helped to reduce differences between full and half irrigation. Further work is required to determine the optimum combination of water application frequency and grazing management of pasture. Our results suggest that, by using high stocking rates, there may be savings in land and water presently used for tropical grass, and these savings could be used for alternative pastures or crops.

Milk yields averaged 16 kg/hd/d in this experiment and, allowing for the production from the grain supplement, estimated average production achieved from the pasture was 10 kg/hd/d. This is similar to the production achieved in earlier experiments (Ehrlich *et al.* 2003), suggesting that using this tropical grass pasture as the forage input and providing moderate concentrate levels would limit milk production to around 16–18 kg/hd/d through the summer and autumn period.

As in many previous studies, stocking rate had a dominant effect on milk output per hectare, with increasing stocking rate increasing milk production per hectare. However, where the stocking rate was increased over 3.5 cows per hectare, animal liveweight declined to levels that could reduce production in subsequent lactations. Tropical grass pastures can support a high stocking rate over the summer and autumn, and our results show a rate of 3.5 cows per hectare is readily achieved with irrigation (Ehrlich *et al.* 2003). Where alternative feeds can be used to maintain cow liveweight, the rate can be increased to 6 cows per hectare without any detrimental effect on pasture growth or vigour.

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